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ABSTRACT

The mathematics unit is presented to assist apprentices to acquire a general knowledge of mathematic skills. The unit consists of nine modules: (1) basic addition, subtraction, multiplication, and division; (2) conventional linear measure; (3) using the metric system, (4) steps to take in solving problems, (5) how to calculate areas and volumes, (6) basic principles of algebra, (7) finance--how to compute wages, payroll deductions, interest rates, and business expenses, (8) statistics and graphs, and (9) how to use the slide rule. Each module contains information on the following areas: objectives, references (textbooks), content, instructional suggestions, and background information. (EC)

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MATHEMATICS

UNIT 6

A CORE CURRICULUM OF RELATED INSTRUCTION FOR APPRENTICES

The University of the State of New York/THE STATE EDUCATION DEPARTMENT
Bureau of Occupational and Career Curriculum Development Albany, New York 12234
1974

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FOREWORD

Apprentice training is a systematic way of providing the skilled workers necessary to supply current and future employment demands. Related instruction is an integral part of a planned apprentice training program — ranking in importance with the skills learned on the job. The related instruction provided to apprentices helps them better understand the trade and to know *why* things are done as well as *how* they are done.

A *Core Curriculum of Related Instruction for Apprentices* was designed to provide relevant instruction to apprentices preparing for a variety of trades. It includes the general topics appropriate to all who will be taking their place in the national workforce. Therefore, presentation of related instruction to a mixed group of apprentices becomes a feasible and manageable activity which helps fulfill the legal requirement for this component of a full apprentice program. It leaves the trade-specific information to be provided as the need arises.

The core curriculum is developed in major units or general topics. Modules within each unit are designed as self-contained instructional packages which can be selected for presentation to meet individual and program needs. The objectives of each module are expressed in terms of expected terminal performances which each apprentice should exhibit as a result of instruction. This allows any apprentice who is able to accomplish the student objectives to move on to another module. The program provides sufficient flexibility for the development of instruction to meet the specific needs of a variety of apprentices with differing backgrounds and expectations.

This unit, *Mathematics*, is one of nine units that have been developed to provide the apprentice with a practical understanding of basic mathematical skills. The Administrative Considerations and Instructional Considerations which will be helpful to administrators and journeymen/instructors in developing and conducting an approvable course in related instruction are contained in Unit I, Introduction to Apprenticeship. It is suggested that reference to that unit be made by all who will instruct this unit.

Content relating to the core curriculum was developed under grant at the New York State School of Industrial and Labor Relations, Cornell University, Ithaca, under the supervision of Professor Felician F. Foltman. Assistance relating to content was provided by Charles A. Stebbins, Associate in the Bureau of Trade and Technical Education, with the concurrence of Carl G. Benenati, Chief, who is responsible for the approval and conduct of related instruction programs for apprentices. The material developed was adapted to a curricular format and prepared for publication by Nelson S. Maurer, Associate in the Bureau of Occupational and Career Curriculum.

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CONTENTS

	Page
Foreword	3
Module 1 — Basic Addition, Subtraction, Multiplication, and Division	5
Module 2 — Conventional Linear Measure	10
Module 3 — Using the Metric System	14
Module 4 — Steps to Take in Solving Problems	20
Module 5 — How to Calculate Areas and Volumes	22
Module 6 — Basic Principles of Algebra	25
Module 7 — Finance: How to Compute Wages, Payroll Deductions, Interest Rates, and Business Expenses	28
Module 8 — Statistics and Graphs	31
Module 9 — How to Use the Slide Rule	34

UNIT 6

MODULE 1

BASIC ADDITION, SUBTRACTION, MULTIPLICATION, AND DIVISION

Explains how to solve problems involving addition, subtraction, multiplication, and division of whole numbers, common fractions, and decimal fractions

OBJECTIVES

At the completion of this module students will be able to:

1 *Define terms related to computation with whole numbers and/or give examples of each term*

2 *Define and/or identify prime and composite numbers and factors of composite numbers*

3 *Find the next term in an arithmetic or geometric number series*

4 *Solve word problems involving addition, subtraction, multiplication, and division of whole numbers*

5 *Define terms used in computations with common fractions and/or give an example of each term*

6 *Solve word problems involving addition, subtraction, multiplication, and/or division of common fractions and mixed numbers*

7 *Solve word problems involving the use of decimal fractions*

8 *Convert common fractions to decimal fractions and vice versa*

REFERENCES

(A) Derryck, D.A. *Mathematics for apprenticeship.* New York, N.Y. Institute of the Joint Apprenticeship Program. 1969.

(B) Jones. O.D. *Applied industrial mathematics.* Englewood Cliff, N.J. Prentice-Hall, Inc. 1947. (Publication out of print, may be available through local library.)

(C) New York State Education Department, Bureau of Continuing Education Curriculum Development. *Teaching adult basic computation: intermediate level.* Albany, N.Y. The Bureau. 1970.

(D) Olivo, C.T. & Olivo, T.P. *Basic mathematics simplified.* Albany, N.Y. Delmar Publishers. 1972.

(E) Schaaf, W.L. *Elementary mathematics.* New York, N.Y. John Wiley and Sons, Inc. 1960. (Publication out of print, may be available through local library.)

(F) Van Leuven, E.P. *General trade mathematics;* 2d ed. New York, N.Y. McGraw-Hill Book Co., Inc. 195[illegible].

CONTENT	INSTRUCTIONAL SUGGESTIONS	BACKGROUND INFORMATION
Terms Related to Whole Numbers (1)	*Use a pretest to determine the mathematical needs of the apprentices and adjust the content of this unit to meet those individual needs. Assistance for selecting such a pretest may be obtained from the staff of the Bureau of Pupil Testing and Advisory Services of the New York State Education Department Washington Ave., Albany, N.Y. 12234.*	
• Integer (1)		Integers are the positive and negative whole numbers and zero.
• Cardinal Numbers (1)		Cardinal numbers indicate quantity such as 15 bolts, 12 panels, or 18 gallons.
• Ordinal Numbers (1)		Ordinal numbers indicate order or rank such as first, second, or third.
	Mathematical rules and procedures along with practical problems may be found in the various suggested references.	
• Digit and Place (1)	Demonstrate the concept of digits and place value by having the students develop a number system using symbols other than numbers. If possible, use fewer than 10 symbols to illustrate a system other than base 10. (Ref. D, pp. 1-2; Ref. E, pp. 1-2; Ref. F)	A digit is any single number such as 2, 5, or 8. Its value is determined according to its place value or its place in a number. For example, in the number 234 the place value of the 2 is hundreds, of the 3 is tens, and of the 4 is ones. Thus, the number means 2 hundreds, 3 tens or 30, and 4 ones or 4.
Prime and Composite Numbers and Factors of Composite Numbers (2)		

CONTENT	INSTRUCTIONAL SUGGESTIONS
• Prime Number (2)	
• Composite Number (2)	
• Factors of a Composite Number (2)	
Arithmetic Number Series (3)	*The review of number series will ascertain whether or not the students are competent in basic addition and multiplication before proceeding to work problems. (Ref. A, p. 110.)*
Geometric Number Series (3)	
Word Problems Involving Whole Numbers (4)	*When needed, provide practice with word problems involving whole numbers which relate to each student's occupational needs. (Ref. B, pp. 3-9, 12-17; Ref. D, pp. 2-16; Ref. F)*
• Addition (4)	
• Subtraction (4)	
• Multiplication (4)	

BACKGROUND INFORMATION

A prime number is one that can be divided evenly only by itself and 1.

A composite number is one that can be divided evenly by numbers other than itself and 1.

Factors of a composite number are numbers by which the composite number can be divided evenly. The factors of a prime number are the prime number itself and 1.

An arithmetic number series is formed by adding or subtracting the same number (or the same pattern of numbers) to each succeeding term, for example the series of 7, 10, 13, and 16.

A geometric series is formed by multiplying or dividing each succeeding term by the same number, for example, the series of 3, 6, 12, and 24.

8

The following terms are used when describing addition problems:

- Addend is a number that is added to other numbers
- Sum or total is the result of the addition

Subtraction is when the sum and one addend is known and the other addend is needed. The result of the subtraction is called the difference or result.

Check the answer of a subtraction by adding the difference or result to the known addend. The answer should be the same as the original sum.

The two numbers being multiplied are called factors and the result is called the product.

CONTENT	INSTRUCTIONAL SUGGESTIONS	BACKGROUND INFORMATION
• Multiplication (4) (cont'd)		To check a multiplication answer, reverse the two factors and rework the problem. The results should be the same.
• Division (4)		In division, the product and one factor are known and the other factor is needed. The product is divided by the known factor and the answer is the other factor which is called the quotient. To check a division answer, multiply the quotient or answer by the other factor. The result should be the same as the original product.
Terms Related to Common Fractions (5)	Discuss with students the various terms related to common fractions and give examples of each term. (Ref. D, pp. 20-21; Ref. F).	
• Denominator (5)		The denominator, or bottom number in a fraction, indicates the equal number of parts into which the unit has been divided.
• Numerator (5)		The numerator, or top number in a fraction, indicates the number of equal parts of the denominator that have been designated or taken.
• Proper Fraction (5)		A proper fraction is one in which the numerator is less than the denominator.
• Improper Fraction (5)		An improper fraction is one in which the numerator is greater than the denominator.
• Mixed Number (5)		A mixed number is composed of a whole number and a proper fraction.
• Lowest Common Denominator (5)		When working with two or more fractions, the lowest common denominator is the smallest number into which the denominator of each fraction can be divided evenly.
Word Problems Involving Common Fractions and Mixed Numbers (6)	*When needed provide practice with word problems involving common fractions which relate to each student's occupational*	

CONTENT	INSTRUCTIONAL SUGGESTIONS	BACKGROUND INFORMATION
• Lowest Common Denominator (6)	*needs. (Ref. B, pp. 29-47; Ref. C, pp. 35-45, 48-56; 66-69; Ref. D, pp. 26-45; Ref. F)*	To add or subtract fractions, the denominators of all the fractions must be the same or have the lowest common denominator. The lowest common denominator is the lowest number into which each of the denominators can be divided evenly.
• Reducing Fractions to Lowest Terms (6)		Except in adding and subtracting fractions, when the lowest common denominator is necessary, it is easier to work with fractions that have been reduced to their lowest terms. The results of adding or subtracting fractions that have to be changed to their lowest common denominators should be reduced to their lowest terms. The results of multiplying and dividing fractions should be reduced to their lowest terms.
Word Problems Involving Decimal Fractions (7)	*When needed, provide practice with word problems involving decimal fractions which relate to each student's occupational needs. (Ref. C, pp. 70-79; Ref. D, pp. 46-69; Ref. F)*	When there are more digits to the right of the decimal than are needed for the accuracy of the problem, it is necessary to round off to the desired degree of accuracy.
Converting Common Fractions to Decimal Fractions and Vice Versa (8)	*When needed, provide practice with problems involving converting common fractions to decimal fractions and decimal fractions to common fractions which relate to each student's occupational needs. (Ref. C, pp. 80-84; Ref. D, pp. 63-64; Ref.)*	In a common fraction when the numerator is divided by the denominator the result is the equivalent decimal fraction. A decimal fraction may be considered a common fraction with a denominator of 10 or some power of 10.

UNIT 6

MODULE 2

CONVENTIONAL LINEAR MEASURE

Identifies the commonly used units of conventional linear measure

OBJECTIVES

At the completion of this module students will be able to:

1 *Define and use the conventional units of linear measure*

2 *Convert from one unit of conventional linear measure to another*

3 *Find linear measurements of any given object within a specified degree of accuracy by direct and indirect methods using appropriate measuring units and tools*

REFERENCES

(A) Olivo, C.T. & Olivo, T.P. *Basic mathematics simplified.* Albany, N.Y. Delmar Publishers. 1972.

(B) Schaaf, W.L. *Elementary mathematics.* New York, N.Y. John Wiley and Sons, Inc. 1960. (Publication out of print, may be available through local library.)

(C) Van Leuven, E.P. *General trade mathematics.* 2d ed. New York, N.Y. McGraw-Hill Book Co., Inc. 1952.

CONTENT	INSTRUCTIONAL SUGGESTIONS	BACKGROUND INFORMATION
Conventional Units of Linear Measure (1)	Have the students give the common units of linear measure used in their respective trades. Point out that some trades work primarily with large units of measure while others generally use small units of measure.	The U.S. is the only large industrialized country not using the metric system but there is a general movement to adopt the metric units as the primary source of measure for the Nation. During the transition period, the conventional units will still be in use.
	Have students give examples of where linear metric units are also being used in their trade.	
	Discuss with students the need of having accurate standard units of measure. (Ref. A, pp. 70-72; Ref. B)	The National Bureau of Standards is responsible for the precise definition of the various units of measure. Because there is nothing in nature which corresponds to a yard or a foot, the definitions of these units are arbitrary and expressed in metric terms.
	Have students suggest situations in which it would be important to have the	The U.S. prototype meter, which is kept at the National Bureau of Standards in Washington, D.C., is the primary standard of length

CONTENT	INSTRUCTIONAL SUGGESTIONS	BACKGROUND INFORMATION
Conventional Units of Linear Measure (1) (cont'd)	National Bureau of Standards verify specific measurements and/or measuring instruments.	in the U.S. The yard is defined as 0.9144 meter. The conventional units are also defined in terms of each other such as, 1 mile equals 1760 yards, 1 yard equals 3 feet, 1 foot equals 12 inches, and 1 inch equals one-twelfth of a foot. Scientists are concerned that the prototypes might be destroyed. Thus, a search continues for a national standard that is invariant in nature, indeperdent of man's devices, and can be easily and accurately reproduced. At present, light radiated by the element krypton-86 is used as the standard for the meter.
Conversion from One Unit of Conventional Linear Measure to Another (2)	*Although all students should be able to convert from one unit of linear measure to another, devise, when necessary, practice problems which relate to each student's occupational needs. (Ref. A, pp. 95-96)*	Many calculations involving measurements require conversion from one unit to another. For example, when estimating the material needed for a particular job, it may be necessary to convert floor tiles that are measured in inches to feet of floor space. When going from a small unit to a larger unit, divide the given measurement by the number of small units in one of the larger units, and express the quotient in terms of the larger unit. When going from a large unit to a smaller unit, multiply the given measurement by the number of smaller units contained in one of the larger units, and express the product in terms of the smaller unit.
Precision and Accuracy (3)	Discuss with students the need for establishing tolerances. Point out the importance of being certain that a desired measurement is within the allowed tolerances and of not wasting time trying to be more precise than is necessary. (Ref. B, pp. 217-221)	The degree of precision refers to the greatest possible or maximum error (one half of the smallest unit applied) and is expressed as follows: • ± correction • "To the nearest ..." • By the position of the last significant figure.

CONTENT	INSTRUCTIONAL SUGGESTIONS	BACKGROUND INFORMATION
Precision and Accuracy (3) (cont'd)		Accuracy refers to the relationship between the maximum error allowed and the actual measurement (maximum error over the actual measurement). Thus, a measurement of 32 feet (384 inches)± 1/2 inch is more accurate than a measurement of 4 feet (48 inches)± 1/2 inch. Accuracy may be expressed as: • Decimal relative error (1/2 inch maximum error in 32 feet equals .0013) • Parts per ... (1/2 inch maximum error in 32 feet equals (1 part per 768) • Percentage (1/2 inch maximum error in 32 feet equals .13 percent)
Measuring Tools (3)	Have students discuss the various measuring tools used in their trades and indicate situations where each tool would be appropriate and the degree of accuracy possible in each case. (Ref. A, pp. 72-83; Ref. C) *When necessary, provide practice in measuring various relevant objects which will give students an opportunity to improve their proficiency in measuring in relation to their individual occupational needs.*	The decision of which tools to use depends to some extent on the tools available. Although the tools commonly used vary among trades, for this module, the students should be able to use at least rules, tapes, micrometers, and calipers.
Direct and Indirect Measuring (3)	Discuss with students direct and indirect methods of measuring. (Ref. A, p. 71; Ref. C)	Direct measurement is when a measuring tool is applied directly to the object being measured. When the direct method is inconvenient or impossible, the measurement may be found indirectly through computation.

CONTENT	INSTRUCTIONAL SUGGESTIONS	BACKGROUND INFORMATION
Direct and Indirect Measuring (3) (cont'd)	*Use line drawings for measuring only when they relate to blueprint reading. Otherwise, use real objects that students are apt to encounter in their respective trades. Provide practice in both direct and indirect methods of measuring.* *During practice periods supervise students carefully to see that they are using correct procedures.*	

USING THE METRIC SYSTEM

Explains the fundamental concepts of the metric system and the problems related to the use of the system as the Nation's primary source of measurement

OBJECTIVES

At the completion of this module students will be able to:

1 *Explain the basis of the metric system*

2 *Use the various units of metric measurement*

3 *Change metric units to conventional units and conventional units to metric units*

4 *Discuss the impact of legislation in promoting this Nation's change to the metric system*

REFERENCES

(A) Beloit Tool Corp. *Discover ... why metrics.* Roscoe, Ill. Swani Publishing Co. 1972.

(B) Cameron, C. A. *Going metric with the U.S. printing industry.* Rochester, N.Y. Rochester Institute of Technology. 1972.

(C) J.J. Keller and Associates, Inc. *Metrication handbook.* Neenah, Wis. The Corporation. 1974.

(D) Olivo, C.T. & Olivo, T.P. *Basic mathematics simplified.* Albany, N.Y. Delmar Publishers. 1972.

(E) Sellers, R.C. *Basic training guide to the new metrics and SI units.* Washington, D.C. National Tool, Die and Precision Machining Association. 1972.

BACKGROUND INFORMATION

CONTENT	INSTRUCTIONAL SUGGESTIONS
The Metric System (1)	*Obtain metric rules and tapes for demonstration and student use.* *Metric information and materials may be obtained from:* *National Bureau of Standards* *Metric Information Office* *Washington, D.C. 20234* *Materials from the above source available from:*

CONTENT	INSTRUCTIONAL SUGGESTIONS	BACKGROUND INFORMATION
The Metric System (1) (cont'd)	*Supt. of Documents, U.S. Government Printing Office Washington, D.C. 20402* *Swani Publishing Co. Roscoe, Ill, 61073* *American National Metric Council 1625 Massachusetts Ave. N.W. Washington, D.C. 20036* *Metric Association, Inc. Sugarloaf Star Route Boulder, Colo. 80302* Discuss with students the basis of the metric system and why a commonly agreed upon measurement system is needed in today's world. (Ref. A, pp. 16-18, 20, 39; Ref. B, pp. 19-21; Ref. C, pp. 43, 50, 53-54; Ref. D, pp. 118-119) *Additional information may be found in:* • *The April 1974 issue of School Shop published by Prakken Publication, 416 Longshore Drive, Ann Arbor, Mich. 48107* • *Copies of Metric News published by Swani Publishing Co. Roscoe, Ill. 61073.*	The metric system, known as the International System of Units (SI), simply and logically coordinates seven basic units of measure into one decimal system. A base unit has been established for each type of measurement. Larger and smaller units are indicated by prefixes which are multiples or submultiples of the basic unit For units larger than the base, the prefixes used are: • deka (da) for tens or 10 times base • hecto (h) for hundreds or 100 times base • kilo (k) for thousands or 1,000 times base For units smaller than the base, the prefixes used are: • deci (d) for tenths or 1/10 base • centi (c) for hundredths or 1/100 base • milli (m) for thousandths or 1/1000 base Changing from one value to another is accomplished by either multiplying or dividing the base by 10, 100, or 1000.

CONTENT	INSTRUCTIONAL SUGGESTIONS
The Metric System (1) (cont'd)	• *"Your Schools Will Be Teaching It and You'll Be Living It ... Very, Very, Very Soon" found on pages 21-27 in the July 1973 issue of American School Board Journal* • *Reference C, pages 118-125*
Basic Metric Units (2) • Meter (2)	Discuss with students the various units of metric measurement. (Ref. A, pp. 22-31; Ref. B, pp. 21-24; Ref. C, pp. 44-49, 51, 58-65, 72-74; Ref. D, pp. 118-119) *Develop practical and relevant problems that require measuring with metric rules and types which will give students an opportunity to use these devices and develop the proficiency needed in relation to their individual occupational needs.*

BACKGROUND INFORMATION

The meter(m) is the basic metric measurement of length. It is a little longer than a yard and used to measure large objects and short distances. For shorter lengths, the centimeter(cm), which is one-hundredth of a meter, is used. For example, 2 1/2 centimeters are just under 1 inch, 10 centimeters just under 4 inches, and 30 centimeters just under 1 foot.

For fine measurements the millimeter(mm), which is one-thousandth of a meter is used. For distances, the kilometer (km) which is one thousand meters, is used. A kilometer is just over one-half mile. The following are commonly used metric units of linear measure:

• millimeter	mm	1 mm = 0.001 m
• centimeter	cm	1 cm = 0.01 m, 10 mm
• meter (base)	m	1 m = 10 dm, 100 cm, 1000 mm
• kilometer	km	1 km = 1000 m

The present international prototype of the meter is based on a specified number of wavelengths of the orange-red line produced by krypton 86. This new definition of a meter is based on a natural standard which is invariant, independent of man's devices, and can be reproduced, when needed, relatively easily and accurately.

CONTENT	INSTRUCTIONAL SUGGESTIONS	BACKGROUND INFORMATION
• Kilogram		The kilogram (kg) is the basic metric unit of mass. It is a thousand grams and the only basic unit that uses a prefix. A kilogram is the weight of one thousand cubic centimeters of water which is just under 2 1/4 pounds. The kilogram is used because the gram (g) is too small for most practical purposes. The gram is about the weight of a paper clip. The following are commonly used metric units of mass: • gram g 1 g = 0.001 kg • kilogram (base) kg 1 kg = 1000 g • ton (metric) t 1 t = 1000 kg The kilogram is actually a measure of mass, but in practical usage the terms of weight and mass are often interchanged.
• Liter		The liter (l) is the basic unit of fluid or volume measure. It is the volume of one thousand cubic centimeters and is a little over 1 quart.
Changing Metric Units to Conventional Units and Vice Versa	Show how to use conversion charts to change from conventional units to metric units and vice versa. (Ref. A, p. 41; Ref. C, pp. 101-107; Ref. D, pp. 119-124; Ref. E, pp. 1-15) Have students discuss whether the real need during the transitional period is to convert from one system to the other or to compare one system with the other. (Ref. C, pp. 53-54) Have students develop a chart that shows conversion factors for commonly used units and a chart that compares basic units	Charts are available of metric and conventional equivalents. To change from one system to the other, multiply or divide by the approximate conversion factor. The ability to "Think Metric" should be promoted to eliminate or reduce the need to change from one system to another. To make using the metric system easier, remember that a: • Meter is a little longer than a yard • Kilometer is a little longer than one-half a mile • Liter is a little larger than a quart • Gram is a little more than the weight of paper clip • Kilogram is just under 2 1/4 pounds.

CONTENT	INSTRUCTIONAL SUGGESTIONS	BACKGROUND INFORMATION
Changing Metric Units to Conventional Units and Vice Versa (cont'd)	of conventional measure with corresponding units of metric measure. (Ref. C, pp. 75-81) *Conversion charts are readily available from numerous sources. See recent copies of Metric News or the April 1974 issue of School Shop.* *Provide problems that will develop the proficiency needed to change units from one system of measurement to the other which relate to each student's occupational needs. (Ref. D, pp. 124-127)*	
Impact of Legislation Promoting the Change to the Metric System • Uniformity with Rest of World	Discuss with students the impact on business, industry, and the individual of this Nation's eventual change to the metric system. (Ref. B, pp. 33-47, 65-75; Ref. C, pp. 53-54, 83-100)	The U.S. is the only large industrialized country uncommitted to the metric system. Late in 1975, the President signed legislation designed to accelerate the use of the metric system as the primary system of measurement for the U.S. It is estimated that this country loses $600 million in foreign trade because its products are not compatible with foreign measurement standards. Some industries already rely on metric standards such as the aerospace and pharmaceutical industries. IBM, Ford, and General Motors have announced plans to design new products with metric specifications and phase out the use of conventional measurements.

CONTENT	INSTRUCTIONAL SUGGESTIONS	BACKGROUND INFORMATION
• Consumer Problems	Have students suggest different circumstances in which they encounter or use metric units in their daily activities. (Ref. A, pp. 19-21, 42-43; Ref. C, p. 55)	The metric system may well influence people's private lives before it effects their occupational activities. It will take time to become accustomed to the metric system so people should be encouraged to "Think Metric" and to use metric measurements frequently which will help them develop a working knowledge of how to deal with the common units of metric measure.

APPROXIMATE CONVERSION CHARTS

FROM METRIC TO CONVENTIONAL

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

FROM CONVENTIONAL TO METRIC

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

STEPS TO TAKE IN SOLVING PROBLEMS

Suggests good work habits for solving mathematical problems

OBJECTIVES

At the completion of this module students will be able to:

1 *Decide the degree of accuracy desirable for a given problem*

2 *Draw a diagram to illustrate a problem*

3 *Locate and use appropriate tables*

4 *Estimate the answer to check accuracy of results*

REFERENCES

(A) Olivo, C.T. & Olivo, T.P. *Basic mathematics simplified.* Albany, N.Y. Delmar Publishers. 1972.

(B) Slade, Samuel, Margolis, Louis, & Boyce, John. *Mathematics for technical and vocational schools;* 5th ed. New York, N.Y. John Wiley and Sons. 1968.

CONTENT	INSTRUCTIONAL SUGGESTIONS
Desired Accuracy for a Given Problem (1)	Discuss with students various factors they need to consider when solving mathematical problems. (Ref. A, pp. 173-178; Ref. B)
• Accuracy of Given Data (1)	Have students indicate how they have approached the solution to various types of mathematical problems they have encountered on the job. Ask students to comment on the effectiveness of the method they selected and to suggest better methods, if they exist.
• Purpose of Calculation (1)	
• Given Tolerances (1)	*Develop practical situations that require solutions to mathematical problems which will give students an opportunity to improve these skills in relation to their individual occupational needs.*

BACKGROUND INFORMATION

In most cases the answer to a problem need not be more accurate than the data used to find the answer. That is, if data on which the problem is based are rounded off to whole numbers, an answer figured to several decimal places is unnecessary.

If measurements made to solve the problem are made with a rule calibrated in sixteenths of an inch, the answer should be to the nearest sixteenths of an inch. However, if measurements are taken to the nearest thousandth of an inch with a micrometer, the answer should be to the nearest thousandth of an inch.

If the problem is to find the area or weight of an object in order to estimate the amount of material necessary for a job, the answer may not have to be as accurate as the solution of a problem to find the size of a part which must fit closely with another part.

If the instructions for a job state the allowed tolerances, it is a waste of time to calculate the solution to a higher degree of accuracy than required.

CONTENT	INSTRUCTIONAL SUGGESTIONS	BACKGROUND INFORMATION
Illustrate Problems with Diagram (2)		If a problem involves an unfamiliar shape or a complicated relationship among information given, it is helpful to diagram the problems and label the parts about which information is known and the parts which must be calculated to solve the problem.
Use of Appropriate Tables (3)		The use of tables can save considerable time and reduce the possibility of making an error in the calculation. These tables usually include the square, cube, square root, and cube root of numbers from 1 to 1000. They may also give the circumference and area of circles with diameters from 1 to 1000 units. Other tables which may be useful on the job include decimal and common fraction equivalents, metric-conventional measurement equivalents, and tables of weights of common materials.
Estimate Answer to Check Accuracy of Results (4)		In many cases an incorrect answer is the result of a misplaced decimal point or the omission of a step in the computation. In these cases the incorrect answer will be vastly different from the correct one and even a very rough estimate of the answer should show the difference. Round off data used for caluclating the answer as much as necessary to make calculations easy. Calculate the answer using rounded off data. Check this result against the result using the exact data, keeping in mind that the greater the difference between the exact data and the rounded off data, the greater the difference between the exact answer and the estimate will be.

HOW TO CALCULATE AREAS AND VOLUMES

Explains how to use formulas for calculating surface areas of rectangles, triangles, parallelograms, trapezoids, circles and sectors of circles, and the volume of rectangular and cylindrical solids

OBJECTIVES

At the completion of this module students will be able to:

1 *Calculate the area of rectangles, parallelograms, triangles, and trapezoids*

2 *Calculate the area of circles and sectors of circles*

3 *Calculate the volume of rectangular solids*

4 *Calculate the volume of a right cylinder or prism*

REFERENCES

(A) Hobbs, G.M. & McKinney, James. *Practical mathematics*, 3d ed. Chicago, Ill. American Technical Society. 1973.

(B) Olivo, C.T. & Olivo, T.P. *Basic mathematics simplified.* Albany, N.Y. Delmar Publishers. 1972

(C) Slade, Samuel, Margolis, Louis, & Boyce, John. *Mathematics for technical and vocational schools;* 5th ed. New York, N.Y. John Wiley and Sons. 1968.

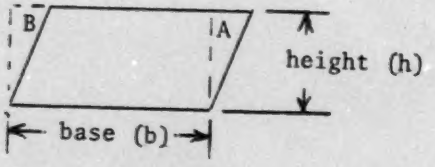
(D) Wolfe, J.H. & Phelps, E.R. *Practical shop mathematics*, Vol. I; 4th ed. New York, N.Y. McGraw-Hill Book Co., Inc. 1959.

CONTENT	INSTRUCTIONAL SUGGESTIONS
Area of Rectangles (1)	Explain how to calculate areas and volumes of different figures. (Ref. A; Ref. B, pp. 93-101; 106-111; Ref. C; Ref. D)
• Applied to Parallelograms (1)	Demonstrate the relationships among rectangles without using geometric theorems. Figures may be drawn on graph paper and similar figures cut apart and laid over them.

BACKGROUND INFORMATION

The area of a rectangle equals the length multiplied by the width (A = lw). Length and width must be expressed in the same units and the answer is expressed in square units.

The formula for the area of a parallelogram is the base times height where the height is the distance between the two bases (A = bh). The relation between a rectangle and a parallelogram may be demonstrated graphically by cutting off triangle A and applying it as triangle B to the other side. Thus, the two triangles formed are equal.

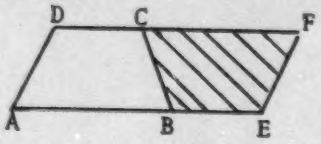


CONTENT	INSTRUCTIONAL SUGGESTIONS
• Applied to Triangles (1)	
• Applied to Trapezoids (1)	
Area of Circles and Sectors of Circles (2)	

BACKGROUND INFORMATION

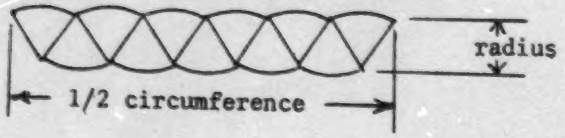
The area of a triangle is equal to one-half of the base multiplied by the height (A = 1/2 bh). As might be inferred from this formula, a triangle is actually half of a parallelogram.

A trapezoid may be extended to form a parallelogram.



The base of this parallelogram is AB plus BE. Therefore, the area of the trapezoid is one-half of the sum of the bases times the height.

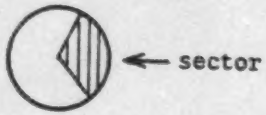
If a circle is divided into an equal number of parts and the triangles thus formed are stretched out along two parallel lines, a figure almost like a rectangle is formed.



As the number of triangles is increased, the shape of the figure formed more closely resembles a rectangle with height equal to the radius of the circle and length equal to one half of the circumference of a circle. By substituting these values, the formula for area of a circle can be derived:

- $A = 1/2\ C \times R$ Where $C = 2\pi R$
- $A = 1/2\ (2\pi R)R$
- $A = \pi R^2$

A sector is the area between the center and the circumference of a circle within a given angle. It is a fraction of the circle equal to the number of degrees in the angle divided by the number of degrees

CONTENT	INSTRUCTIONAL SUGGESTIONS	BACKGROUND INFORMATION
Area of Circles and Sectors of Circles (2) (cont'd)		in a circle (360°). Thus, to find the area of a sector, multiply the area of a circle with radius equal to a side of the sector by the number of degrees in the angle of the sector divided by 360. 
Volume of Rectangular Solids (3)		
• Principles (3)	Ask students to calculate the capacity of rectangular tanks (1 gal. equals 231 cu. in.) or the weight of a given object when the weight by volume of the material is known.	A cubic unit is the space occupied by a block one unit long, one unit high, and one unit deep. Just as surface area is the product of two dimensions, volume is the product of three dimensions.
• Procedures (3)		To find volume of a rectangular solid, express the lengths, height, and depth in common units and compute the product of length, height, and depth. Express the answer in cubic units.
Volume of Right Cylinders and Right Prisms (4)	Show students how to compute the volume of irregular objects composed of these shapes.	A right cylinder consists of two round bases of equal diameter between a straight lateral surface, which is perpendicular to the bases A right prism consists of two polygonal bases of equal shape and size between a straight lateral surface, which is perpendicular to the bases. Right prisms are named according to the shape of the base. To find the volume of a right cylinder or right prism, compute the area of the base and multiply by height. Express the answer in cubic units.

BASIC PRINCIPLES OF ALGEBRA

Explains the principles of algebra necessary to solve problems on the job, including algebraic equations and ratio and proportion problems

OBJECTIVES

At the completion of this module students will be able to:

1 *Perform arithmetic operations with positive and negative numbers*

2 *Solve numerical problems involving parentheses and other grouping symbols*

3 *Solve linear equations involving algebraic symbols*

4 *Solve problems involving ratios and proportions*

REFERENCES

(A) Slade, Samuel, Margolis, Louis, & Boyce. John. *Mathematics for technical and vocational schools*, 5th ed. New York, N.Y. John Wiley and Sons. 1968.

(B) Wolfe, J.H. & Phelps, E.R. *Practical shop mathematics*, Vol. I; 4th ed. New York, N.Y. McGraw-Hill Book, Co., Inc. 1959.

CONTENT	INSTRUCTIONAL SUGGESTIONS	BACKGROUND INFORMATION
Arithmetic Operations Involving Positive and Negative Numbers (1)	*Provide word problems for practice that involve the basic principles of algebra which are relevant and related to the occupational needs of each student.* (Ref. A; Ref. B)	
• Addition (1)		To add two positive numbers, add their absolute values and prefix the answer with a plus sign. To add two negative numbers, add their absolute values and prefix the answer with a minus sign. To add a positive and a negative number, find the difference and prefix the answer with the sign of the larger number.
• Subtraction (1)	*The Listening Library of 1 Park Ave., Old Greenwich Conn. 06870 offers a set of six color filmstrips*	To subtract a positive and negative number, change the sign of the subtrahend and proceed as with addition.

CONTENT	INSTRUCTIONAL SUGGESTIONS	BACKGROUND INFORMATION
• Multiplication (1)	*entitled, "Modern Algebra Series," which provides visual development of such topics as exponents, signed numbers, laws of operation, inequalities, solving equations, and graphing equations. There is also available materials on Intermediate Algebra covering the basic laws of algebra, fractions, first degree equations, graphs, and logarithms.*	The product of two numbers having the same sign is positive.
• Division (1)		The product of two numbers with different signs is negative. The quotient of two numbers having the same sign is positive. The quotient of two numbers with different signs is negative.
Numerical Problems Involving Parentheses and Other Grouping Symbols (2)		To solve numerical problems involving parentheses and other grouping symbols the multiplication and division are completed first and the addition and subtraction are done last. Parentheses are used to indicate that the operation within parentheses must be performed first. Also, parentheses are used instead of the multiplication sign.
Linear Equation Involving Algebraic Symbols (3)		A linear equation is a statement of equality between number and/or algebraic symbols raised to the first power only. When working with a linear equation, the same number may be added to or subtracted from both sides without changing the balance of the equation. Also, each member of an equation may be multiplied or divided by the same number without changing the balance of the equation.
Ratios and Proportions (4)		A ratio of one quantity to another is the first quantity divided by the second. A proportion is an equality of two ratios. $\frac{a}{b} = \frac{c}{d}$ or a:b::c:d.

CONTENT

Ratios and Proportions (4) (cont'd)

INSTRUCTIONAL SUGGESTIONS

BACKGROUND INFORMATION

In a proportion the first and fourth terms are the extremes and the second and third are the means.

The following theorems apply to proportions:

- In any proportion, the product of the means is equal to the product of the extremes, for example, if $\frac{a}{b} = \frac{c}{d}$ then $ad = bc$.
- The mean proportional between two quantities is equal to the square root of their product, for example, if $\frac{x}{y} = \frac{y}{y}$ then $y = \sqrt{x^2}$.
- If four quantities are in proportion, they are in proportion by alternation, for example, if $\frac{a}{b} = \frac{c}{d}$ then $\frac{a}{c} = \frac{b}{d}$.
- If four quantities are in proportion, they are in proportion by inversion, for example, if $\frac{a}{b} = \frac{c}{d}$ then $\frac{b}{a} = \frac{d}{c}$.
- If four quantities are in proportion, they are in proportion by composition, for example, if $\frac{a}{b} = \frac{c}{d}$ then $\frac{a + b}{b} = \frac{c + d}{d}$.
- If four quantities are in proportion, they are in proportion by division, for example, if $\frac{a}{b} = \frac{c}{d}$ then $\frac{a - b}{b} = \frac{c - d}{d}$.
- In a series of equal ratios, the sum of all the numerators is to the sum of all the denominators as any one numerator is to its denominator.

UNIT 6

MODULE 7

FINANCE: HOW TO COMPUTE WAGES, PAYROLL DEDUCTIONS, INTEREST RATES, AND BUSINESS EXPENSES

Presents the principles of computing wages, payroll deductions, interest, and cost of discounts used in business

OBJECTIVES

At the completion of this module students will be able to:

1 *Compute wages earned under different pay systems*

2 *Calculate payroll deductions*

3 *Compute interest on loans or savings accounts*

4 *Calculate manufacturing costs*

REFERENCES

(A) Olivo, C.T. & Olivo, T.P. *Basic mathematics simplified.* Albany, N.Y. Delmar Publishers. 1972.

(B) Van Leuven, E.P. *General trade mathematics;* 2d ed. New York, N.Y. McGraw-Hill Book Co., Inc. 1952.

CONTENT	INSTRUCTIONAL SUGGESTIONS
Computing Wages (1)	Discuss with students why it is important to be able to compute or at least estimate one's wages and to indicate the records necessary to make this computation. (Ref. A, pp. 148, 151-155; Ref. B, pp. 131-134, 147-159)
• Hourly rate (1)	
• Piece Rate (1)	
Payroll Deductions (2)	
• Social Security (2)	

BACKGROUND INFORMATION

To compute wages under an hourly system, simply multiply the number of hours worked by the hourly rate. It is necessary to have complete information about different rates paid for late shifts, overtime and holidays.

The piece rate system is based on the number of pieces produced multiplied by the rate for each piece. Usually a higher rate is paid for pieces produced over a certain quota.

Check with the local Social Security Office for the current tax rate and the maximum taxable income. To calculate the payroll deduction, ascertain the percentage the employee must pay and multiply by weekly earnings. Note: Social Security deductions should stop each year if the maximum taxable income is passed.

CONTENT	INSTRUCTIONAL SUGGESTIONS	BACKGROUND INFORMATION
• Income taxes withheld (2)		The withholding tax, like income tax, is based on the amount of income minus allowable exemptions and deductions. To calculate the withholding tax, check with the IRS Office for the current tax rate and the allowed deduction per dependent. Divide the allowed deduction by the number of pay periods per year and multiply by the number of dependents. Subtract this from income per pay period and multiply this taxable income by the current tax rate for the appropriate income bracket.
• Other Deductions (2)		Check with the employer regarding the method of computing other deductions such as savings plans, unemployment insurance, and life and health insurance.
Interest Charges on Loans and Savings (3)		Interest is the amount of money paid for the use of someone else's money. Principal is the amount of money used. Rate is the percentage of the principal paid as interest. Compounding period is the length of time after which the interest is added to the principal. Interest equals the principal multiplied by the rate multiplied by the length of time the money is used. Care must be taken to express all values in the appropriate units. Thus, if the interest rate is annual, the time must be calculated in years or fractions of a year.
Computing Manufacturing Costs (4)		
• Materials (4)		Materials are usually purchased in large amounts. To find the cost per item produced, it is necessary to calculate how much of a given material is in each item and divide the total cost of the large amount of material by the percentage of that amount in each item.

CONTENT	INSTRUCTIONAL SUGGESTIONS
• Labor (4)	
• Overhead (4)	
• Manufacturing Costs (4)	

BACKGROUND INFORMATION

To compute the cost of labor per item produced find out how many items are produced in a certain time period and divide the labor cost for that time period by the number of items produced.

To compute the cost of overhead per item produced, add overhead costs such as advertising or building maintenance over a given time period and divide by the number of items produced in that time period.

To determine the manufacturing cost per item, add together the per unit costs for materials, labor, and overhead.

UNIT 6

MODULE 8

STATISTICS AND GRAPHS

Explains how to calculate and apply percentages and averages and how to construct and interpret bar, circle, and line graphs

OBJECTIVES

At the completion of the module students will be able to:

1 *Define and calculate percent*

2 *Identify and discuss applications of percentage*

3 *Identify and interpret circle, bar, and line graphs*

4 *Construct circle, bar, and line graphs*

5 *Delineate major uses of each type of graph*

6 *Define and calculate average*

7 *Discuss applications of average*

REFERENCES

(A) Hobbs, G.M. & McKenney, James. *Practical mathematics;* 3d. ed. Chicago, Ill. American Technical Society. 1973.

(B) Olivo, C.T. & Olivo, T.P. *Basic mathematics simplified.* Albany, N.Y. Delmar Publishers. 1972.

(C) Slade, Samuel, Margolis, Louis, & Boyce, John. *Mathematics for technical and vocational schools;* 5th ed. New York, N.Y. John Wiley and Sons. 1968.

(D) Wolfe, J.H. & Phelps, E.R. *Practical shop mathematics,* Vol. I; 4th ed. New York, N.Y. McGraw-Hill Book Co., Inc. 1959.

32

CONTENT	INSTRUCTIONAL SUGGESTIONS
Percents (1)	*Provide word problems for practice involving statistics and graphs which are relevant to the occupational needs of each student.*
Applications of Percents (2)	
• Job Related (2)	

BACKGROUND INFORMATION

Percent means hundredths part of the whole, for example, 15 percent equals .15. To find the percent, change the percent to a decimal or common fraction and multiply the given number by the decimal or fraction.

Percents are used on the job for:

- Composition of mixture
- Mechanical efficiency
- Error rates and waste material

CONTENT	INSTRUCTIONAL SUGGESTIONS	BACKGROUND INFORMATION
• Business (2)		Percents are used in business for: • Discount rates • Labor costs • Profits
• Off the Job (2)		Percents are used off the job for: • Interest rates • Cost of living increases • Opinion poles
Circle Graphs (3)	Ask students to bring to class different kinds of graphs and have them interpret the information shown. (Ref. A; Ref. B; pp. 158-172; Ref. C, pp. 168-181)	A circle graph is a circle divided into sectors with each sector representing a percentage of the whole. Circle graphs can be interpreted generally by visually judging the relative sizes of each sector. Interpretation of specific information depends on whether the sectors of the graph are labeled in absolute quantities or percentages.
Bar Graphs (3)	*Listening Library, 1 Park Ave., Old Greenwich, Conn. 06870 offers a black and white filmstrip entitled, "What Is A Graph?" covering line, bar, pie, and picture graphs.*	A bar graph uses solid lines or bars of a certain length to represent given quantities. Bar graphs may include a scale at least the length of the longest bar to indicate how many units are represented by a given interval on the bar. Like the circle graph, the bar graph can be interpreted roughly by judging the relative length of the bars. Bars may be labeled with specific information or may be measured against the scale to obtain specific information.
Line Graphs (3)		A line graph shows, by means of a straight, curved, or broken line, the relationship between two types of information. Trends can be interpreted from line graphs by examining the direction the line slants. Specific information may be obtained by finding a known value on either the horizontal or vertical scale and reading the adjacent value on the other scale.
Construction Circle Graphs (4)	Ask students to construct graphs of things they are involved in such as a line graph of daily production	Use the following procedures to construct a circle graph: • Add all items to be shown to determine the whole. • Find what percent of the whole each item is.

CONTENT	INSTRUCTIONAL SUGGESTIONS	BACKGROUND INFORMATION
Construction Circle Graphs (4) (cont'd)	over a specified time and a circle graph of a family budget. (Ref. B, pp. 158-172; Ref. C)	• Multiply each percent by 360 to find the number of degrees in each part. • Draw a circle and divide it into the appropriate parts. • Label the graph and each sector.
Construction Bar Graphs (4)		Use the following procedures to construct a bar graph: • Determine the scale of the graph, or how many units will be represented by each interval of the bar according to scale. • Draw a bar for each quantity given. • Label the graph, scale, and each bar.
Constructing Line Graphs (4)		Use the following procedures to construct a line graph: • Determine and label horizontal and vertical scales. • Plot given pairs of members. • Connect points with broken, curved, or straight lines depending on the relationship of the data. • Label the graph.
Uses for Circle Graphs (5)		A circle graph can be used when data to be graphed represent all parts of some whole.
Uses for Bar Graphs (5)		Bar graphs are useful to depict visually the relationship between related pieces of information.
Uses for Line Graphs (5)		Line graphs are usually used when there is some causal relationship between the two types of information or some trend over time.
Average (6)	Ask students to average the data used for the graphs they previously constructed.	Average generally means a quantity with a value that is intermediate between two or more quantities. To compute an average find the sum of all the quantities and divide the total by the number of quantities added.
Application of Averages (7)		An average can be used for estimating materials needed for a job. Businessmen rely on information such as average cost per unit. People frequently rely on information such as average rainfall, bowling average, or stock market averages.

HOW TO USE THE SLIDE RULE

Explains short cuts in computations possible with the slide rule

OBJECTIVES

At the completion of this module students will be able to:

1 *Describe the parts, scales, and divisions of the slide rule*

2 *Multiply two three-digit numbers using the slide rule*

3 *Divide three-digit numbers using the slide rule*

4 *Find the square and square root of a number using the slide rule*

5 *Find cubes and cube roots using the slide rule*

REFERENCES

(A) Harris, C.O. *Slide rule simplified;* 3d ed. Chicago, Ill. American Technical Society. 1972.

(B) Jones, O.B. *Applied industrial mathematics.* Englewood Cliffs, N.J. Prentice-Hall, Inc. 1947. (Publication out-of-print, may be available through local library.)

(C) Slade, Samuel, Margolis, Louis, & Boyce, John. *Mathematics for technical and vocational schools;* 5th ed. New York, N.Y. John Wiley and Sons. 1968.

(D) Wolfe, J.H. & Phelps, E.R. *Practical shop mathematics;* 5th ed. New York, N.Y. McGraw-Hill Book Co., Inc. 1968.

CONTENT	INSTRUCTIONAL SUGGESTIONS
Parts, Scales, Divisions of Slide Rule (1)	Explain the parts, scales, and divisions of the slide rule. (Ref. A; Ref. B, pp. 9-10; Ref. C)
• Parts (1)	
• Scales (1)	*Valiant Instructional Materials Corporation, 237 Washington Ave., Hackensack, N.J. offers a super 8 film loop series on the slide rule covering such topics*

BACKGROUND INFORMATION

The parts of the slide rule include:

- Rule — the main body of the instrument
- Slide — the moveable center part of the instrument
- Runner — the clear moveable part with the vertical hairline marking

The C scale on the slide and the D scale on the rule are identical. They are used for multiplying and dividing.

The A scale on the rule and the B scale on the slide are identical. They are composed of two A or B scales, and are used to extract square root and to find the area of circles.

CONTENT	INSTRUCTIONAL SUGGESTIONS	BACKGROUND INFORMATION
• Scales (1) (cont'd)	*as reading and handling the slide rule, multiplication, division, squares, cubes, roots, and practice problems.*	The K scale is composed of three C or D scales and is used to find cube roots and volume of spheres.
• Divisions (1)		The C and D scales are divided into ten main divisions progressively smaller toward the right. Each of these divisions is subdivided into 10 parts. From 1 to 2 each subdivision is further divided into 10 parts. From 2 to 4 each subdivision is divided into five parts. From 4 to 10 each subdivision is divided in half. The A and B scales are divided into 100 main divisions progressively smaller toward the right. From 1 to 10 each division is subdivided into 10 subdivisions. From 1 to 2 each subdivision is divided into five parts, from 2 to 5 each subdivision is divided in half and from 5 to 10 the subdivisions are not further divided. From 10 to 20 each division is subdivided into five parts. From 20 to 50 each division is subdivided in half and from 50 to 100 there are no subdivisions. The K scale has 1,000 main divisions, with 1 to 3 subdivided into 10 parts and each divided further in half, 3 to 6 subdivided into 10 parts, 6 to 10 subdivided into 5 parts, 10 to 30 subdivided into 10 parts each and divided further in half, 30 to 60 subdivided into 10 parts, 60 to 100 subdivided into 5 parts, 100 to 300 divided into 10 subdivisions and each divided in half, 300 to 600 subdivided into 10 parts and 600 to 1000 subdivided into 5 parts.
Multiplication (2)	Show how to multiply two three-digit numbers using the slide rule. (Ref. C; Ref. D) *Provide problems for practice involving the slide rule for multiplication, division, squares and square roots, and cubes and cube roots. The problems should be relevant and the proficiency developed should be related to occu-*	To multiply using the slide rule: • Set the index (the numeral 1) of the C scale directly over one of the factors on the D scale. • Move the runner to the other factor on the C scale. • Read the answer under the hairline on the D scale. To locate the decimal point by estimation round off the factors and multiply them to estimate the number of places in the answer. To locate the decimal point by the characteristic of: • Whole numbers — one less than the number of digits

CONTENT	INSTRUCTIONAL SUGGESTIONS
Multiplication (2)	*pational needs of each student.* *Much of the work involving the slide rule can be accomplished with a small inexpensive electronic calculator.*
Division (3)	
Squares (4)	

BACKGROUND INFORMATION

- Mixed numbers — one less than the number of digits left of the decimal
- Fractions — number is negative and indicated by the position, of the first digit, other than zero, to the right of the decimal

In multiplication, add the characteristics of the factors to find the characteristics of the product, except if the left end of the C scale extends to the left end of the D scale, then add one to the characteristics of the product.

To divide using the slide rule:

- Set the divisor on the C scale above the dividend on the D scale.
- Read the answer under the index of the C scale.

To locate the decimal point by estimation, round off and execute the division to estimate the number of places in the answer.

To locate the decimal point in the answer by characteristic, subtract the characteristic of the division from the characteristic of the dividend.

To use the slide rule to find the square of a number.

- Set the runner on the number to be squared on the D scale.
- Read the answer under the hairline on the A scale.
- Estimate product to locate the decimal.

To locate numbers on the A scale:

- If the first significant figure is an odd number of places before the decimal point or an even number of places after the decimal point the numbers are on the left end of the scale.
- If the first significant digit is an even number of places before, or an odd number of places after the decimal point, the numbers are on the right end of the scale.

CONTENT	INSTRUCTIONAL SUGGESTIONS	BACKGROUND INFORMATION
Square Roots (4)		To use the slide rule to find the square root of a number: • Set the runner on the number on the A scale and read the answer under the hairline on the D scale. • Estimate root to locate decimals.
Cubes (5)		To use the slide rule to find the cube of a number: • Set the C index to the given number on scale D and read the cube on scale A above the given number on the B scale, or • Set the runner on the given number on the C scale and read the answer under the hairline on the K scale.
Cube Roots (5)		To use the slide rule to find the cube root of a number: • Divide the given number into periods, each having three digits. If the first period has one significant figure, set the runner on the given number on the left part of the A scale. If the first period has more than one significant figure, set the runner at the given number on the right part of the A scale. • Move the slide until the number on D under the C index is the same as the number on B under the hairline. • Read the answer either on B under the hairline or on D under the C index. or, • Find the answer on the D scale opposite the given number on the K scale. To determine which part of the K scale to use, separate the given number into periods. If the first period has one digit, use the left section of the K scale. If it has two digits, use the middle section, and if three digits, use the right section.